Imaging the Cervical Spine following rugby related injury

Background

Two differing codes of rugby have existed since 1895 and are played on a global scale with particular focus on the former British Empire and France. It is generally accepted that the game is a high energy, contact sport and that participation comes with a significant risk of injury. The risk has increased over time with greater advantage being gained from having larger and stronger participants, particularly at the highest level[1]. The changes in physiology and anthropometrics of rugby have led to greater physicality and an increased incidence of musculoskeletal injury. The nature of the game involves repeated exposure to impacts which have reported in terms of g force as high as 7-10g during professional games[1]. The majority of these musculoskeletal injuries will not be considered life threatening or life altering but a significant risk of cervical spine injury (CSI) exists for participants which renders the prospect of paraplegia or tetraplegia and have association with significant morbidity and mortality for both players of rugby union and rugby league. The consequences of more serious CSI for the participants, the immediate family and for wider healthcare is highly significant. Fuller (2007) concluded that the level of risk for what were described as "catastrophic injuries" suffered in English rugby union fell into the Health and Safety Executive's guide values for an "acceptable" level of risk which was defined as "a risk in the region of 1 in one million of a serious adverse occurrence"[2]. There are estimated to be 2.5 million registered rugby union players in England 2011 [3]. The number of rugby league participants is rumoured to be around 250,000 in England which is considerably lower and is testament to the more geographically restricted area that the game is traditionally associated with. In combination, rugby represents one of the biggest sports played in the UK.

Given the consequences of CSI, correct clinical and radiological diagnosis is imperative to ensure correct management. Traditionally, this would have involved conventional radiography. Anecdotal evidence suggests that the required visualisation of the cervicothoracic junction in rugby players with broad shoulders is problematic for radiographers who resort to additional views in order to visualise this important region. The consequences of additional views include delayed diagnosis[4] and additional ionising radiation to the head and neck region. Further complications of radiological diagnosis can exist if the patient is paediatric and clinicians are unfamiliar with the appearances of a paediatric cervical spine[5].

The traditional imaging of the cervical spine in trauma situations has been three views, the anteroposterior C3-C7, lateral supine and anteroposterior C1-C2 "open mouth" projections. Sloane et al (2010)'s most recent Clark's radiographic positioning textbook discusses the difficulties encountered with the lateral supine projection. The need to visualise the cervicothoracic junction is appreciated and the use of traction is suggested to visualise up to one additional vertebra. Should the use of traction be unsuccessful, swimmer's lateral, oblique projections or CT should be considered. Given the body habitus of rugby players, the additional vertebra seen through traction is unlikely to be sufficient[6].

With the increased use of CT scanning in trauma and the additional benefit that it can bring in assessment of the cervical spine, the continued use of both conventional radiography or additional views could be questioned. Traditionally, radiographers have reverted to trauma obliques or "swimmers" views in an attempt to visualise the cervicothoracic junction. The long held argument

against CT scanning was that it was perceived as a high radiation dose modality but with more recent developments, the radiation dose has been reduced to such a point that the continued use of additional views, particularly in patients with high suspicion of injury, could be rendered obsolete.

Causation of injury

Given the distribution of both codes of rugby, much of the literature in relation to the sport comes from predominantly a limited number of countries but from a wide geographical spread.

Berry et al (2006)'s analysis of spinal injuries in rugby union and rugby league between 1986 and 2003 identified the tackle and the scrum as occasions that created the greater risk of spinal injury. Due to technical aspects of the sport, the scrum in rugby league presented less of a risk which was further highlighted by the statement that the risk of tetraplegia was four times higher in rugby union than in rugby league. They concluded that an urgent need to further improve safety in both codes of rugby was needed[7].

Dennison et al (2012) analysed spinal injuries in rugby union alone[8]. They agree with Berry et al (2006) in that the majority of CSI occur during the tackle or the scrum but they examine the biomechanics further and question the belief that hyperflexion is the more prevalent cause of CSI pointing to a more diverse range of causes. However, what is stated is that the opportunity for hyperflexion and axial loading to the cervical spine should be minimised[7]. Fuller et al (2007) identified a change in the scrummaging laws in rugby union had reduced cervical spine injuries[2]. An interesting comparison can be made with American Football which saw the incidence of cervical quadriplegia drop dramatically from a peak of 34 cases to 5 per season via simple changes to the rules of the sport to reduce the incidence of axial loading type injuries[9]. High impact sport needs to continue to be vigilant in the causation of CSI injuries and instigate prevention mechanisms when appropriate.

From an imaging perspective, the origins and biomechanics of the CSI are important but it is the clinical examination of the patient that is significant, both in terms of subsequent imaging and for the long term prognosis. The significance is that the CSI represents a more established risk in rugby than in other sports although pastimes like horse riding and diving also have greater risk. The risk for rugby league players alone was cited by Hoskins et al (2006) as 1.5 per 100000 players which may seem small but needs seeing in context with the catastrophic consequence for the individual[10]. This particular study originates in Australia which, unlike most other countries, rugby league is the dominant code. Kuster et al (2012) cited a potential highest figure of 13 per 100000 players for rugby union in the UK[11]. Imaging remains an important part of any investigation of suspected CSI.

Clinical examination

Hardy and Snaith (2011) state that patients should be presumed to have a spinal injury until proven otherwise and that a systematic trauma assessment using the <C>ABC approach should be initiated and immobilisation applied. Initial pitch-side assessment would look to establish the risk of CSI[12].

The NEXUS and Canadian cervical spine rules exist to assist clinicians in assessing the cervical spine. Nexus refers to midline tenderness, intoxication, alertness, focal neurological deficit and distracting

injuries whereas the Canadian rules refer to “dangerous mechanism”, one of which is axial loading in combination with questions on movement and rotation. The sensitivity of the rules are generally accepted to be good but there are questions with regard their specificity[13]. There is overlap between both rules and the NICE guidelines discussed within the clinical imaging section.

Pattern of injury

Goldberg et al’s 2001 study based on the NEXUS project identified that the greater prevalence of cervical spine fractures and dislocations occur at the C5, C6 and C7 level. The study was based on blunt trauma as an entity rather than sports related but gives a clear pattern of injuries in the lower section of the cervical spine[14]. Given the body habitus of rugby players, this is the area of the cervical spine most likely to be obscured by bone and soft tissue which gives concern as to the potential for injuries being missed. However, Munera et al (2012) commented that pure axial loading of the skull on C1 can result in fractures of the anterior arch of C1 at one or two locations in addition to fractures of the posterior arch meaning that vigilance is needed at all levels of the cervical spine[15].

Clinical imaging

Within the UK, no specific NICE guidance exists in relation to cervical spine alone. The head injury pathway does however refer to CT cervical spine scan within one hour in the presence of “risk factors”; these risk factors are included in table 1. It should be noted that these apply to adults only.

Table 1: Risk factors indicating CT cervical spine scan within 1 hour from NICE[16]

- GCS less than 13 on initial assessment. See recommendations on GCS.
- The patient has been intubated.
- Plain X-rays are technically inadequate (for example, the desired view is unavailable).
- Plain X-rays are suspicious or definitely abnormal.
- A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).
- The patient is having other body areas scanned for head injury or multi-region trauma.
- The patient is alert and stable, there is clinical suspicion of cervical spine injury and any of the following apply:
    - age 65 years or older
    - dangerous mechanism of injury (fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision)
    - focal peripheral neurological deficit
    - paraesthesia in the upper or lower limbs.

The two significant issues that arise from this guidance in the context of rugby related injuries are the technically inadequate x-rays (due to inadequate visualisation of the cervicothoracic junction) and the dangerous mechanism of injury which refers specifically to axial load to the head, the mechanism that is likely to result from rugby.

The RCR guidelines T08 also refers to cervical spine assessment in conscious patients with head and/or facial injury. The authors refer to “dangerous mechanism of injury”. The RCR comment that

CT is undoubtedly more accurate than three-view cervical spine x-ray but carries a higher radiation dose. They also state that CT cervical spine can be undertaken at the same time as a CT head, which could render the undertaking of cervical spine radiography both time consuming and unnecessary. From the perspective of clinical radiography, the RCR's guidance refers to "three view cervical spine x-ray" suggesting that trauma obliques and swimmers views have not been factored in to the radiation dose comparison[17].

There is a general paucity of recent research in relation to use of additional views in cervical spine radiography. Goyal et al (2010) took a more radiography-centric view of the technical aspects that exist in cervical spine imaging[18]. They concluded that use of filters and anti-scatter grids had an impact in visualising the cervicothoracic junction but they also state that CT scanning is likely to replace further views where availability permits as it is quick and gives visualisation in almost 100% of patients. Rethnam et al (2012) concluded that swimmers views did not satisfactorily provide adequate visualisation of the cervical spine in trauma patients, recommending CT as alternative if the lateral radiograph and swimmers views were deemed inadequate which poses the question as to why attempt radiography in the first instance if the mechanism and clinical history is highly suspicious[19]. Indeed Kanji et al (2014)'s systematic review and Raza et al (2013) meta-analysis and cohort study both concluded that multi-detector CT scanning could be used in isolation to clear the cervical spine. Neither of these studies focussed uniquely on rugby or sports injuries but on patients for whom clinical history could be obtained due to patient's level of consciousness[20,21]. The significance that CT scanning can assess the cervical spine accurately remains.

Considering imaging more historically; Woodring and Lee (1993) concluded that radiography could not be relied upon to definitively determine the extent and severity of c-spine injuries. They state that for those patients whose radiography was negative for injury but there was high clinical suspicion, CT scanning should be "liberally employed"[22]. In addition to the diagnostic accuracy, Blackmore et al (1999) undertook a cost effective analysis of CT scanning of the cervical spine, concluding that in both high and moderate risk patients that CT scanning was the most cost effective method of imaging[23]. Considering that in the annals of history, there are question marks over the diagnostic accuracy of cervical spine radiography in conjunction with further question marks on cost effectiveness and time[4]. The evidence relates to a more general population with differing mechanisms of injury and body habitus. If the anecdotal evidence of rugby players being more challenging to image is true, the diagnostic accuracy, cost effectiveness and timeliness of imaging is likely to be a significant factor in this patient demographic.

The factor that was not always considered in the early publications is the ionising radiation dose that the patient may receive. Rugby players tend to be younger males with greater radio-sensitivity. Changes in CT scanning over recent times such as iterative reconstruction have acted to reduce the radiation dose. The iterative reconstruction is particularly significant for larger patients as it allows image noise reduction and improved image quality which would not be possible with older scanners[24]. The combination of iterative reconstruction and automatic tube voltage selection has been shown to reduce dose in larger patients by 35% across all areas of imaging[25]. Bodelle et al (2015) focussed their study specifically on the neck region and identified automated tube potential selection which was software based had the potential to reduce overall radiation dose by approximately 26% which further supports the notion that advances in CT scanning have reduced radiation dose without compromising image quality[26].

Conclusion

There is general agreement that cervical spine radiography lacks the sensitivity of CT scanning in the assessment of the cervical spine in routine patients. Given that the sport of rugby provides opportunities of axial loading by way of the tackle or the collapse of a scrum and in cases where there is strong clinical suspicion, CT scanning as an initial imaging technique would save time and reduce cumulative radiation dose that would occur when radiography and CT scanning are both undertaken. The notion that CT scanning is a modality that always results in a higher radiation dose needs to be seen in a more modern context where considerable advances have been made in dose reduction techniques. The potential impact of direct digital radiography on radiation dose to the cervical spine may challenge this but there is a paucity of research around this area currently and the diagnostic value of radiography versus CT will not be altered by this shift in radiographic practice.

Radiography of the cervical spine represents a considerable challenge in terms of achieving the visualisation of the cervicothoracic junction when the patient is broad shouldered. It is something of a generalisation to describe all rugby players as broad shouldered but the nature of the sport lends itself to such a body habitus meaning that this particular patient group is more challenging for clinical radiographers to visualise the cervicothoracic junction on the lateral supine projection. Multiple attempts at swimmer's projections will confer no radiation protection to the patient. In the event that NICE guidelines are reviewed, the imaging strategy for patients who have suffered what is regarded as a high risk mechanism of injury needs to consider the expanded role of CT scanning.

The continued practice of undertaking radiography on rugby players with suspected cervical spine injury when CT scanning is available should be questioned. However, the impact on imaging department of any change in strategy needs to be carefully considered with particular emphasis put on weekend services when most competitive rugby is played.

The sports of rugby union and rugby league also need to continue to be vigilant to ensure player safety is maintained. There needs to be particular focus on tackling and scrummaging. The latter of which is less of an issue in rugby league where the scrums are not competitive with the focus in keeping the ball in open play. Whereas rugby union may feel that the scrum is an area of the game that is sacrosanct, the introduction of non-competitive scrums could reduce the number of CSI that occur. Brown et al (2014) believed that rugby union could be underestimating scrum related neck injuries due to the lack of focus on the players who make up the front row of the scrum. The purpose of this review is to consider imaging strategy rather than sports administration and rule making but an overall reduction in catastrophic injuries to sports participants can be to everyone's benefit. Further studies focussing specifically on rugby players and imaging of neck injuries in terms of mechanism of injury and radiation dose reduction would help both the sports administrators and departments of radiology.

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